

REMARKS

Claims 8-18 are currently pending in the application. Claims 8-9, 11-12, and 14-17 have been amended. Applicant respectfully submits that independent claims 8 and 14 have been amended per suggestion by the Examiner. Applicant respectfully submits that no new matter has been added. Applicant respectfully requests reconsideration of the application in view of the foregoing amendments and the following remarks.

Claims 8-18 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In response, Applicant has amended independent claims 8 and 14 to remove the term "substantially", which according to the Examiner, rendered the claims indefinite. Withdrawal of the rejection of claims 8-18 is respectfully requested.

Claims 8-13 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,602,839 to Annapareddy et al. ("Annapareddy") in view of "Collective dynamics of 'small world' networks", to Watts et al. ("Watts").

Claim 8 relates to a method for constructing a scalable computer system. Applicant respectfully submits that the cited combination of Annapareddy and Watts fails to teach, suggest, or render obvious at least one of the distinguishing features of independent claim 8, namely, interconnecting a plurality of computing nodes to form a plurality of node clusters, providing a plurality of cross-links between the node clusters, and directly connecting, using the plurality of cross-links, a corresponding plurality of pairs of node clusters selected from the plurality of node clusters in accordance with a selection process resulting in a formation of a network of the plurality of computing nodes having a higher clustering coefficient of nodes in comparison with a corresponding randomly-connected network in combination with a lower characteristic path length between the nodes. In addition, Applicant respectfully submits that the cited references fail to disclose wherein the steps of providing the plurality of cross-links and directly connecting the plurality of pairs of node clusters in accordance with the selection process are repeated until the resulting network comprises a small-world network having an average path length between the plurality of nodes falling within a predetermined desired range, independently of a number of said plurality of computing nodes.

Applicant respectfully submits that historically there have been two main approaches for interconnecting large number of processing nodes. First, a large number of direct connections may be provided between nodes, resulting in a low mean path length between the nodes. This approach results in a substantially quadratic increase in the number of interconnections as the number of nodes are scaled. Second, regular lattice or ring type structures employing mainly local connections between nodes enable a manageable scaling of interconnections as the number of nodes increase. However, this approach requires messages to be routed along multi-hop paths. The path length increases approximately linearly with the size of the system. In the latter approach, propagation and buffering delays ultimately limit the system performance, such that further increase in the number of processing nodes fails to increase in processing capacity.

Applicant respectfully submits that, in accordance with the prior art, the trade off between interconnect complexity and path length exemplified by these two extremes is unavoidable. Therefore, it is not possible to achieve a low mean path length in combination with a low interconnect complexity in a large scale system. As a result, the realization that the small world principle as claimed provides a methodology for designing and constructing massively scaleable systems having precisely this advantage is counter-intuitive in the face of the pre-existing beliefs, and represents a genuine breakthrough in the art.

Applicant respectfully submits that the new solution for interconnecting processing nodes to form scalable systems, as claimed, is quite different from prior art approaches. In particular, the method as defined, for example, in claim 8 comprises three distinct stages in the construction of a scalable computer system. In the first stage, a plurality of computing nodes is interconnected to form a plurality of node clusters. These node clusters are initially unconnected. Accordingly, in a second stage, cross links are provided between the node clusters, such that the clusters become connected. Finally, in a third stage, the cross links are used to directly connect pairs of clusters, which are selected so as to form a network having the desired properties. The second and third stages of the process may be repeated as necessary in order to achieve this goal.

Applicant respectfully submits that the cited art, whether considered individually or in combination, fails to teach, suggest or disclose the three-stage process as claimed. In

particular, the step of first interconnecting nodes to form clusters is not disclosed in any of the cited references, and nor is the step of interconnecting node clusters in order to form a small-world network of the nodes comprising the clusters. The additional level of structure provided to the network via the clustering step contributes substantially to the very high level of scalability enabled, up to at least 256,000,000 processors. Applicant respectfully submits that this degree of scalability is unprecedented in the art.

Annapareddy is cited by the Office Action as disclosing a system comprising a plurality of computing nodes; however, the Office Action concedes that Annapareddy is silent regarding "... selecting the cross-links such that the system comprises a small world network ..." See Office Action, p. 2. Watts has been cited by the Examiner as supplying this deficiency of Annapareddy. Given the above, the Office Action suggests that it would have been an advantageous modification to "...the system disclosed by Annapareddy since it would have significantly reduced the average path length, resulting in reduced latency and more efficient routing on the network, since the average number of hops required to reach a distant node would be decreased".

Applicant first respectfully submits that there is no motivation to combine Annapareddy and Watts. Annapareddy discloses a multinode communication or multiprocessor network in which messages are communicated from one node to another using an adaptive and dynamic routing scheme. The routing scheme includes two-level multi-path routing tables at each node to ensure efficient delivery of the messages. The routing scheme also includes a deflection counter in each message header to avoid endless rerouting of messages and an exponential back off and retry policy to avoid deadlocks. The network depicted in Figure 2 of Annapareddy is a substantially regularly-connected network having a high degree of interconnection and does not exhibit any of the characteristics of a small-world network.

Watts discloses an analysis and a mathematical description of the properties of "small world" networks. Watts discloses that the small world principle can be embodied in a variety of biological, technological, and social networks. Watts further discloses techniques for analyzing existing networks in order to assess the extent to which the existing networks embody the small world principle.

Applicant respectfully submits that the network taught by Annapareddy utilizes an adaptive and dynamic routing scheme which is applicable to prior art multi-processor networks. Annapareddy fails to disclose using novel physical network topologies such as, for example, the small-world network topology to overcome problems of latency and efficient routing. Annapareddy discloses a fully connected network having a substantially one-to-one connectivity which cannot be scaled. More specifically, combining the small world network design with the network design taught by Annapareddy would render the adaptive and dynamic scheme of Annapareddy unnecessary. Therefore, there would be no motivation to utilize the small world principle of Watts with a multinode communication or multiprocessor network in which messages are communicated from one node to another using an adaptive and dynamic routing scheme as disclosed in Annapareddy.

In addition, Watts fails to disclose or suggest directly connecting, using the plurality of cross-links, a corresponding plurality of pairs of node clusters selected from the plurality of node clusters in accordance with a selection process resulting in a formation of a network of the plurality of computing nodes having a higher clustering coefficient of nodes in comparison with a corresponding randomly-connected network in combination with a lower characteristic path length between the nodes as claimed.

Given the above, Applicant respectfully submits that there is no motivation to combine the teachings of Annapareddy and Watts as suggested by the Office Action. Indeed, even if the teachings of Annapareddy and Watts were somehow combined as suggested by the Office Action, Applicant respectfully submits that it is not apparent that the introduction of “a few random links” into the prior art multi-processor network of Annapareddy would result in the conversion of the prior art multi-processor network of Annapareddy into a small world network design as claimed.

For all the foregoing reasons, Applicant respectfully submits that independent claim 8 distinguishes over the cited combination of Annapareddy and Watts and is in condition for allowance.

Dependent claims 9-13 depend from and further restrict independent claim 8 in a patentable sense. Applicant respectfully submits that, for at least the reasons set forth above

with respect to the rejection of independent claim 8, dependent claims 9-13 distinguish over the cited combination of Annapareddy and Watts and are in condition for allowance.

Claims 14-18 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,602,839 to Annapareddy et al. ("Annapareddy") in view of Watts and further in view of U.S. Patent No. 5,859,975 to Brewer et al. ("Brewer").

Claim 14 relates to a method for constructing a large scale computer system. Applicant respectfully submits that the cited combination of Annapareddy, Watts, and Brewer fails to teach, suggest, or render obvious at least one of the distinguishing features of independent claim 14, namely, forming clusters of fully interconnected nodes by arranging a plurality of nodes in a network with neighboring sets of nodes, wherein each node of the plurality of nodes includes a plurality of interconnected processors, providing a plurality of cross-links between selected nodes of different clusters, and directly connecting, using the plurality of cross-links, a corresponding plurality of pairs of the selected nodes of different clusters, said pairs being selected in accordance with a selection process resulting in a formation of a network of said nodes having a higher clustering coefficient of nodes in comparison with a corresponding randomly-connected network in combination with a lower characteristic path length. In addition, Applicant respectfully submits that the cited references fail to disclose wherein the steps of providing the plurality of cross-links and directly connecting the plurality of pairs of the selected nodes of different clusters in accordance with said selection process are repeated until the resulting network comprises a small-world network having an average path length between the plurality of nodes falling within a predetermined desired range, independently of a number of said plurality of nodes. Additionally, Applicant submits that claim 14 patentably distinguishes over Annapareddy and Watts for similar reasons to those discussed above with respect to independent claim 8. Brewer fails to cure the deficiencies of Annapareddy and Watts as discussed earlier. Applicant respectfully submits that independent claim 14 distinguishes over the cited combination of Annapareddy, Watts, and Brewer and is in condition for allowance.

Dependent claims 15-18 depend from and further restrict independent claim 14 in a patentable sense. Applicant respectfully submits that, for at least the reasons set forth above

with respect to the rejection of independent claim 14, dependent claims 15-18 distinguish over the cited combination of Annapareddy and Watts and are in condition for allowance.

Claims 8-12 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over “Small-World Networks: Evidence for a Crossover Picture”, to Barthelemy (“Barthelemy”) in view of Official Notice.

Barthelemy discloses that an onset of small-world behavior is a crossover phenomena and not a phase transition from a large world to a small one. On the basis of the alleged discovery that the exponent τ (introduced on Page 3181 Col. 1 Paragraph 2 of the reference) is less than one, Barthelemy concludes that the rewiring process is highly non-linear and has dramatic consequences on the global behavior of the network, and further that in order to decrease the radius of the network, it is necessary to rewire only a few times (Page 3183 Col. 1 Paragraph 3). However, Applicant notes that in an Erratum (Marc Barthelemy and Luis Amaral, “Erratum: Small-World Networks: Evidence for a Crossover Picture”, 21 June 1999, Physical Review Letters, Vol 82, Number 25, p 5180), the authors subsequently acknowledge that their earlier calculations were incorrect, and that $\tau = 1$, in agreement with expectations. This clearly invalidates the corresponding conclusions of Barthelemy. It is thus difficult to ascertain any disclosure in Barthelemy, when correctly understood in view of the Erratum, that provides any relevant advance over the disclosure of Watts.

It is therefore respectfully submitted that, for at least the reasons set forth above with respect to the rejections based upon Annapareddy and Watts, the claims patentably distinguish over Barthelemy in view of Official Notice.

Applicant respectfully submits that Barthelemy discloses in general the small world network but fails to disclose the method for constructing a scalable computer system as recited in claim 8. More specifically, Applicant respectfully submits that Barthelemy fails to disclose at least one of the distinguishing features of independent claim 8, namely, interconnecting a plurality of computing nodes to form a plurality of node clusters, providing a plurality of cross-links between the node clusters, and directly connecting, using the plurality of cross-links, a corresponding plurality of pairs of node clusters selected from the plurality of node clusters in accordance with a selection process resulting in a formation of a network of the plurality of

computing nodes having a higher clustering coefficient of nodes in comparison with a corresponding randomly-connected network in combination with a lower characteristic path length between the nodes.

The Official Action contends that Barthelemy discloses, at Page 3181 Col. 2 Paragraph 2, interconnecting a plurality of nodes to form a plurality of node clusters, and providing a plurality of cross links between the node clusters. However, the cited passage discloses to “start from a regular one-dimensional network with n vertices, each connected to z neighbors.” Applicant respectfully submits that this is simply a definition of a regular network, and does not correspond with the formation and interconnection of distinct node clusters, as claimed. More specifically, the outcome of the two steps that the Official Action equates with this passage is not a network with n vertices, each connected to z neighbors, but rather is a network comprising a plurality of clusters, wherein the clusters are interconnected using a necessarily smaller number of links (since there are, by definition, fewer clusters than nodes), such that the network is clustered rather than regular.

In addition, Applicant respectfully submits that the cited references fail to disclose wherein the steps of providing the plurality of cross-links and directly connecting the plurality of pairs of node clusters in accordance with the selection process are repeated until the resulting network comprises a small-world network having an average path length between the plurality of nodes falling within a predetermined desired range, independently of a number of said plurality of computing nodes. The Official Notice fails to cure the deficiencies of Barthelemy noted above. Applicant respectfully submits that independent claim 8 distinguishes over Barthelemy and the Official Notice and is in condition for allowance.

Dependent claims 9-12 depend from and further restrict independent claim 8 in a patentable sense. Applicant respectfully submits that, for at least the reasons set forth above with respect to the rejection of independent claim 8, dependent claims 9-12 distinguish over the cited Barthelemy and the Official Notice and are in condition for allowance.

Claims 14-18 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Barthelemy in view of Official Notice and further in view of Brewer.

Claim 14 relates to a method for constructing a large scale computer system. Applicant respectfully submits that the cited combination of Barthelemy, Official Notice, and Brewer fails to teach, suggest, or render obvious at least one of the distinguishing features of independent claim 14, namely, forming clusters of fully interconnected nodes by arranging a plurality of nodes in a network with neighboring sets of nodes, wherein each node of the plurality of nodes includes a plurality of interconnected processors, providing a plurality of cross-links between selected nodes of different clusters, and directly connecting, using the plurality of cross-links, a corresponding plurality of pairs of the selected nodes of different clusters, said pairs being selected in accordance with a selection process resulting in a formation of a network of said nodes having a higher clustering coefficient of nodes in comparison with a corresponding randomly-connected network in combination with a lower characteristic path length. In addition, Applicant respectfully submits that the cited references fail to disclose wherein the steps of providing the plurality of cross-links and directly connecting the plurality of pairs of the selected nodes of different clusters in accordance with said selection process are repeated until the resulting network comprises a small-world network having an average path length between the plurality of nodes falling within a predetermined desired range, independently of a number of said plurality of nodes. Additionally, Applicant submits that claim 14 patentably distinguishes over cited references for similar reasons to those discussed above with respect to independent claim 8. The Official Notice and Brewer fail to cure the deficiencies of Barthelemy as discussed earlier. Applicant respectfully submits that independent claim 14 distinguishes over the cited references and is in condition for allowance.

Dependent claims 15-18 depend from and further restrict independent claim 14 in a patentable sense. Applicant respectfully submits that, for at least the reasons set forth above with respect to the rejection of independent claim 14, dependent claims 15-18 distinguish over the cited combination of Barthelemy, Official Notice, and Brewer and are in condition for allowance.

In view of the above amendment, Applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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